Doppler Effect and Beats

recap from last class

What is sound? Baby don't hertz me.

vibrations you can hear, between 20-20000Hz

Closed tube length = $\lambda/4$ or $3\lambda/4$ or $5\lambda/4$ ...

Open tube length = $\lambda/2$ or $3\lambda/2$ or $5\lambda/2$ ...

Doppler

Look at an airplane that is not moving. What do you notice about the sound waves?

The waves spread out in all directions.

What will the waves look like if the plane moves?

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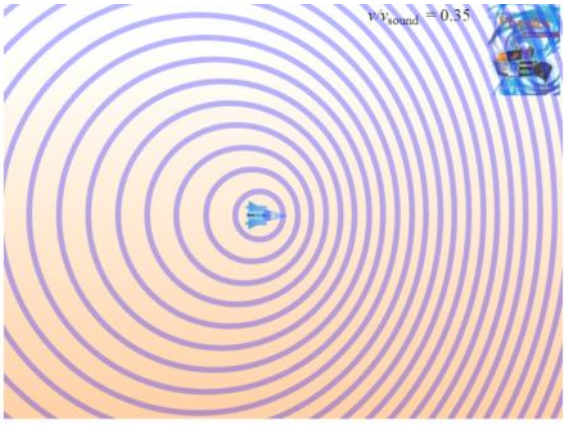
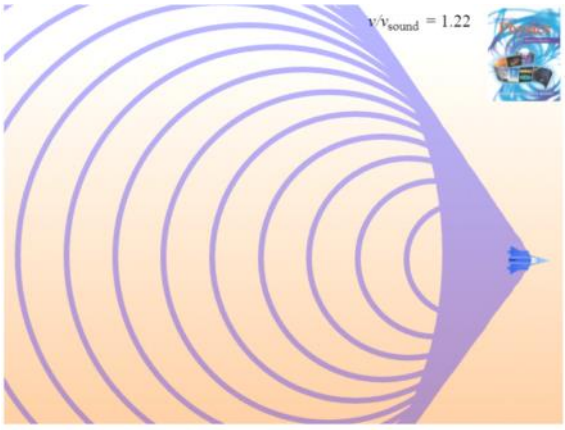


The waves are bunched together in front and spread apart behind. Since the wavelength is shorter in front, the frequency is higher.
Think of the neeeeeeyaoooooo sound of a racecar (neeeee high frequency - high pitch, yaooooow is lower frequency - low pitch)

if the airplane moves faster than the speed of sound, you get a "sonic boom" where the waves add.



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mathy part

$f' = f(v_w+v_o)/(v_w-v_s)$
f' is the observed frequency, in Hz
f is the produced frequency, in Hz
v_w is the speed of the wave, in m/s
v_0 is the velocity of the observer going to the source, in m/s. (negative if going away)
v_s is the velocity of the source going towards the observer, in m/s. (double negative if going away).
eg. A ambulance is producing a 440Hz sound is moving at 30.0 m/s. What frequency do you hear if you are stationary when it
a) moves towards you?
b) moves away from you?

$f' = f(v_w+v_o)/(v_w-v_s)$
$f' = 440Hz(343m/s+0)/(343m/s-30.0m/s)$
$f' = 482Hz$

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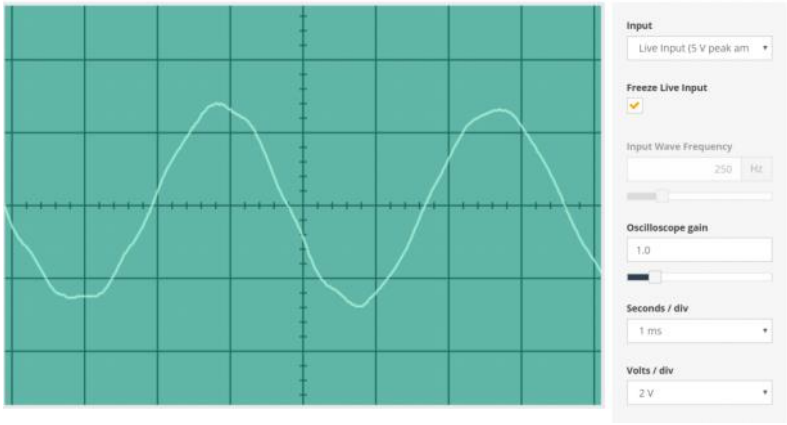
http://www.lon-capa.org/~mmp/applist/doppler/d.htm

http://physics-pages.wikispaces.com/Waves%20and%20Oscillations

https://academo.org/demos/virtual-oscilloscope/

Beats

If two wave sources produce the same frequency sound, the waves add together if they are synchronized.



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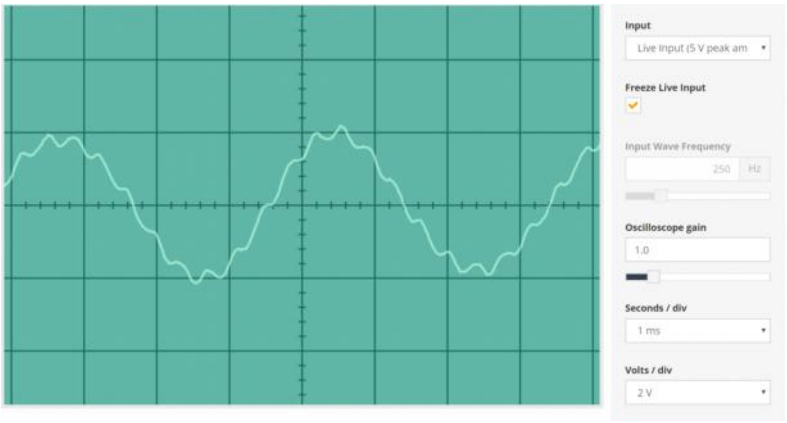
if the waves are way off, a complex wave pattern is produced



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if two waves are close together in frequency, what do you hear?

Video Recording

you hear a "wah wah" sound - called beats.

the frequency of the beat = the difference in frequency of the two sources
$f_b = |f_1 - f_2|$

so if you are hitting a 256 Hz tuning fork and hit another fork and hear 3 Hz beats, what are the possible frequencies of the second fork?

253Hz or 259Hz

p318 Q9,10, p321 Q11,12
p326 Q11,12
p327 Q25 keeners

Video recording started: 9:40 AM Tuesday, April 10, 2018

block 2-3

Doppler Effect and Beats

recap from last class

What is sound? Baby don't hertz me.

vibrations you can hear, between 20-20000Hz

Closed tube length = $\lambda/4$ or $3\lambda/4$ or $5\lambda/4$ ...

spacing = d = $\lambda/2$

Open tube length = $\lambda/2$ or $3\lambda/2$ or $5\lambda/2$ ...

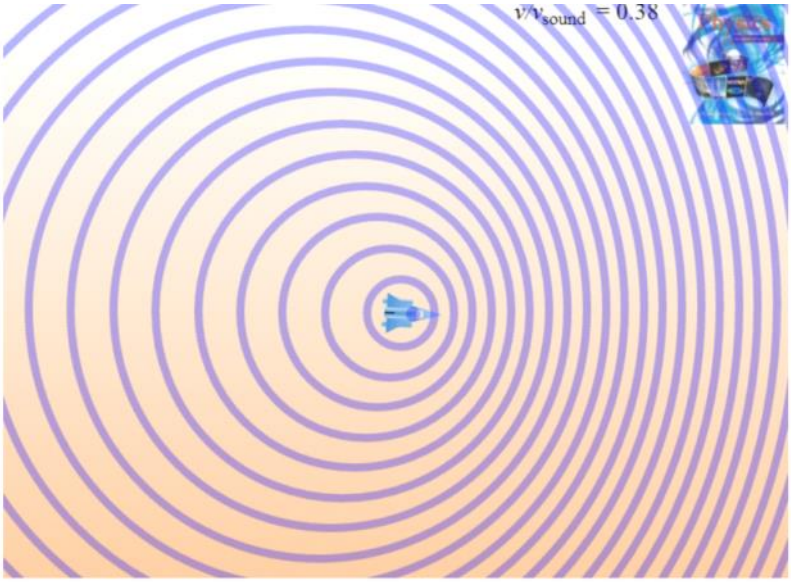
Doppler Effect or Doppler Shift

Look at an airplane that is not moving. What do you notice about the sound waves?

http://www.lon-capa.org/~mmp/applist/doppler/d.htm

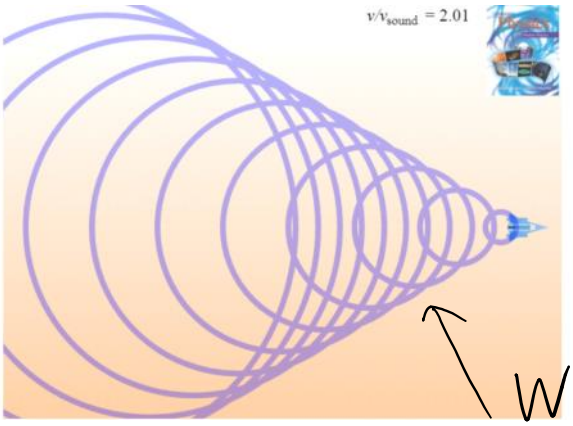
waves spread in all directions

if the plane moves, the waves still move at the same speed, it is determined by the medium.



waves are bunched in front and spread out
in the back.
higher frequency in front - higher pitch
https://www.youtube.com/watch?v=dC4Lp7k4zrI
lower frequency behind, lower pitch
you hear neeeeyowwww as the car goes by
neeee - higher pitch higher frequency
yowwww- lower pitch lower frequency

what if the airplane is supersonic?



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waves bunch up
- add up
- Sonic Boom

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https://www.youtube.com/watch?v=3m5QNhWencQ

mathy part:

$f' = f\,(v_w+v_o)/(v_w-v_s)$
f' is the observed frequency of the emitted wave, in Hz.
f is the produced frequency, in Hz with no relative motion.
v_w the speed of the wave - constant - sound usually say 343m/s at sea level
v_o the velocity of the observer towards the source (negative is move away)
v_s the velocity of the source, in m/s.
eg. you are playing a concert A at 440Hz on your trombone while skiing at 10 m/s. What tone does a stationary observer hear when

a) you are moving towards the observer?
b) you are moving away from the

observer
homework p318 Q9,10
p321 Q11,12
p327 Q25 keeners

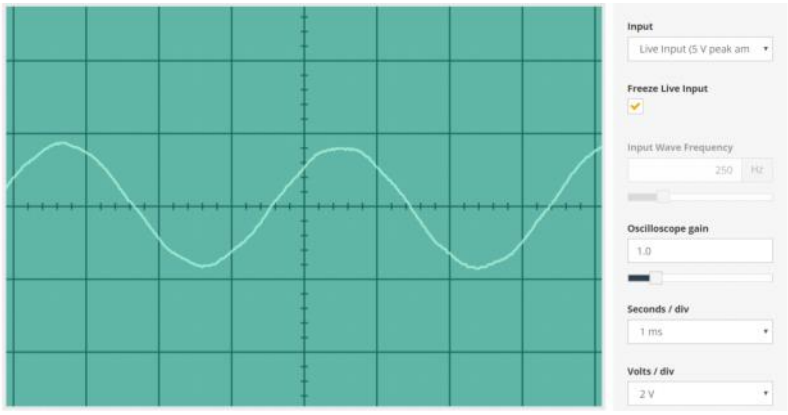
$f' = f\,(v_w+v_o)/(v_w-v_s)$
$= 440\text{Hz}(343\text{m/s}+0)/(343\text{m/s}-10\text{m/s})$
$= 453\text{Hz}$ towards
$= 440\text{Hz}(343\text{m/s}+0)/(343\text{m/s}+10\text{m/s})$
$= 428\ \text{Hz}$

Beats

If you play two sound sources of the same frequency, the tones add together if they are in phase.

Video Recording

https://academo.org/demos/virtual-oscilloscope/



If the two frequencies are a bit off, you hear:

Video Recording

Video Recording

You hear a "wah wah" sound, these are called beats. They are caused by the waves starting in phase and going out of phase periodically.
http://www.walter-fendt.de/html5/phen/beats_en.htm

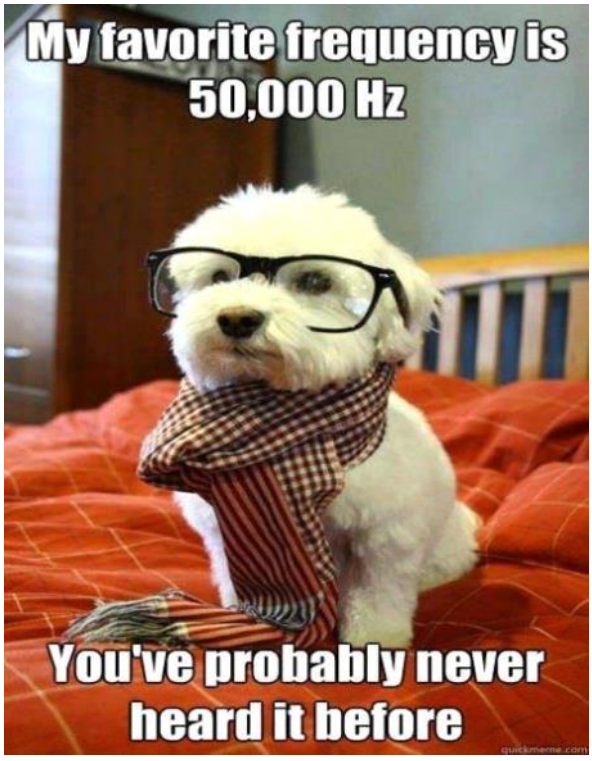
the beat frequency, f_b = the absolute value of the difference of the two frequencies, f_1 and f_2

$f_b = |f_1 - f_2|$

eg. you I hit a tuning fork with 256Hz and hit another fork and hear 3 beats per second, what is the frequency of the second fork?

253 or 259 Hz are possible frequencies
https://www.youtube.com/watch?v=Tn35SB1_NYI

block 2-2
Doppler Effect and Beats



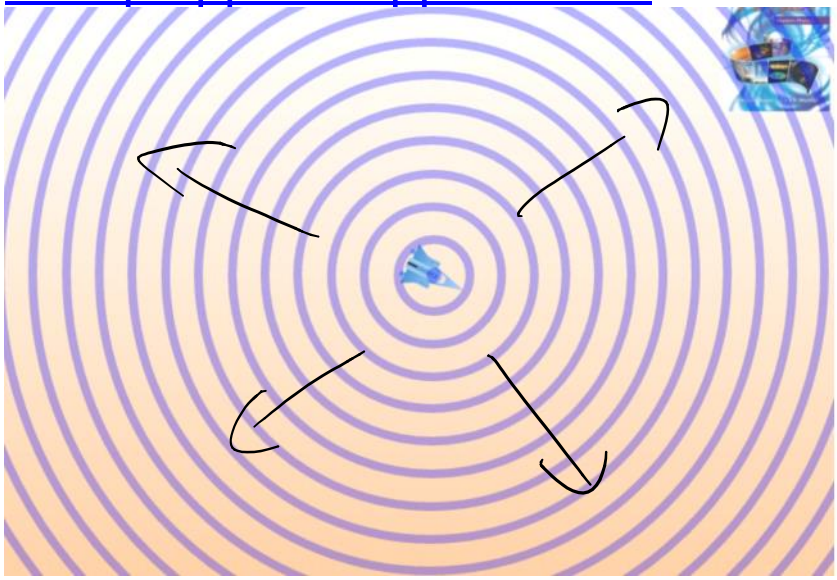
recap from last class
What is sound? Baby don't hertz me.
vibrations you can hear, between 20-20000Hz
Closed tube length = $\lambda/4$ or $3\lambda/4$ or $5\lambda/4$ ...
If I hit a 493Hz tuning fork over a closed tube, what are the first two lengths to resonate? (v=343m/s)
$\lambda = v/f = 343/493 = 0.6957$ m
$L=\lambda/4 = 0.6957/4 = 0.1739$ m
$L=3\lambda/4 = 3x0.6957/4 = 0.5218$ m

spacing = d = $\lambda/2$
Open tube length = $\lambda/2$ or $3\lambda/2$ or $5\lambda/2$ ...

trombone length 3 m, the wavelength will be 6m
L=λ/2, the λ=2L = 2x3=6m
f = v/λ = 343/6=57.1667 about 60Hz

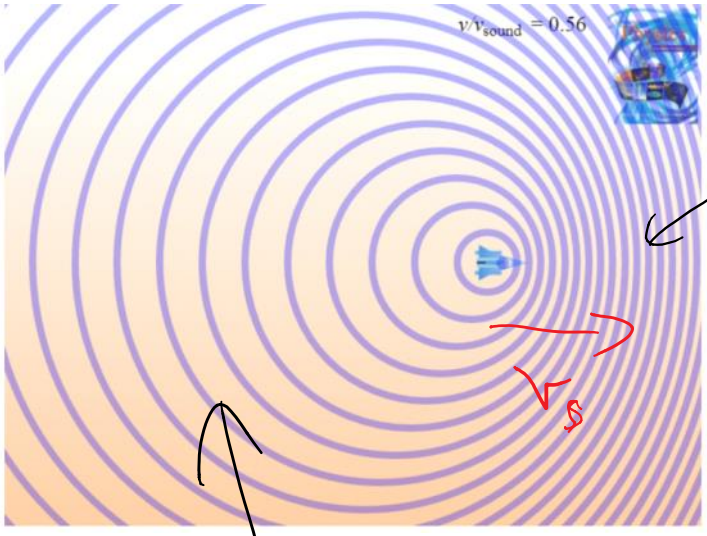
Doppler Effect or Doppler Shift

Look at an airplane that is not moving. What do you notice about the sound waves?
http://www.lon-capa.org/~mmp/applist/doppler/d.htm



Waves move in all directions as circles

what happens if the airplane is moving?



waves in front are bunched

waves behind are spread out

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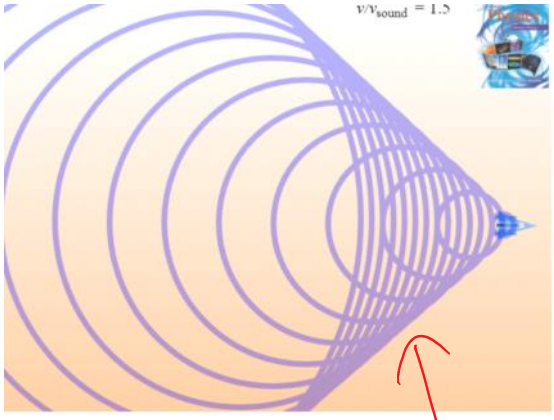
waves behind are spread out

v_s is the velocity of the wave source (to the right)

If the velocity of the source is faster than the velocity of the waves:



faster than sound!

Sonic Boom!

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The sound waves combine together to form a high amplitude wave.

the speed of the waves are independent of the speed of the source

When you look at racecars:

https://www.youtube.com/watch?v=dC4Lp7k4zrI

you hear the Doppler effect as "neeeeyaowwwww"

"neeeee" is when the cars are approaching you higher pitch, higher frequency, shorter wavelength

"yaowwww" is when the car moves away from you

lower pitch, lower frequency longer wavelength

mathy part:

$f' = f(v_w+v_o)/(v_w-v_s)$

f' is the observed frequency, in Hz
f is the produced frequency, in Hz
v_w velocity of the wave, in m/s sound 343m/s at sea level
v_o velocity of the observer towards the source (make negative if they move apart)
v_s velocity of the source towards the observer (make double negative if the move apart)
eg. You play a 440Hz tone on your trombone as you ski at 10 m/s. What tone do you hear as a stationary observer when
a) the trombonist moves towards you?
b) away from you?
https://www.youtube.com/watch?v=3m5QNhWencQ

$f' = f(v_w+v_o)/(v_w-v_s)$
$= 440x(343+0)/(343-10)=453.2132$
450Hz moving towards each other
$= 440x(343+0)/(343+10)=427.5354$
430Hz moving away

Beats:

https://academo.org/demos/virtual-oscilloscope/

Video Recording

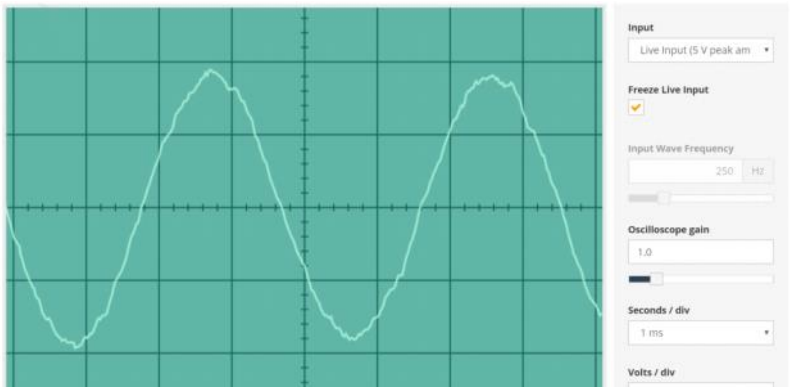
Video Recording

Video recording started: 1:18 PM Tuesday, April 10, 2018

If two wave sources are of the same frequencies , they add together:

Video Recording

Video recording started: 1:20 PM Tuesday, April 10, 2018



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if two waves are close in frequency, you hear

Video Recording

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"wah wah" sound - called beats.

the two waves start in phase but get out of phase http://www.walter-fendt.de/html5/phen/beats_en.htm

this alternating constructive and destructive interference is what produces the beat sound.

the beat frequency, $f_b = |f_1-f_2|$

eg. if you hit a 256 Hz tuning fork and an unknown tuning fork and hear 3Hz beats, what is the frequency of the unknown fork?

253Hz or 259Hz
(256-253)=3
(256-259)=-3

Quiz next class:
p318 Q9,10
p321 Q11,12
p327 Q25 keeners